Mining Foundation Distinguished Lecture

Thursday, April 27, 2017

A Rocky Mountain Hi!

Presented by
Mr. John G. Mansanti
2017 President - The Society for Mining, Metallurgy and Exploration

Reception from 5:00-6:00 p.m.
Marriott Griffin Gate Resort - Lexington, Kentucky
Lecture begins at 6:00 p.m.

Reception Sponsored by Steinert US, Inc.

John G. Mansanti is the Senior Vice President of Strategic Initiatives and Technical Services for Intrepid Potash, Inc. Prior to joining Intrepid he had over 30 years of operations management experience in precious and base metals, managing several of the flagship gold properties in Nevada including Goldstrike, Cortez and Carlin. As a result of mergers and acquisitions he worked for many gold companies most notably Barrick, Placer Dome, Newmont and Freeport. In addition to his experience in the potash and precious metals industries he has process experience with copper, molybdenum, lead and zinc. He has managed open pit, process and underground operations.

Mansanti is currently the 2017 SME president. Throughout his career Mansanti has been recognized within SME as MPD’s Outstanding Young Engineer, a Robert H. Richards Award recipient and a SME Distinguished Member. Mansanti has also been recognized by the Department of the Interior and in 2012 he was awarded the Director’s Excellence Through Leadership Award.

He is a graduate of the Montana College of Mineral Science and Technology with degrees in Chemistry and Mineral Processing Engineering. Mansanti is a registered professional engineer.

He and his wife Margi recently celebrated 35 years of marriage. They have three children, two sons-in-law, five grandchildren and one dog.

For additional Information contact Geaunita Caylor at 859-257-2820 or g.caylor@uky.edu
Evaporation Ponds in Carlsbad New Mexico

April 27, 2017
University of Kentucky
Mining Engineering Foundation

A Rocky Mountain Hi!
John Mansanti 2017 SME President
A graph and table showing the number of fatalities per year in mining and skiing from 2012 to 2016.

**Skiing Claims More Lives per Year than Hardrock or Coal Mining**

<table>
<thead>
<tr>
<th>Year</th>
<th>MSHA Recorded Fatalities</th>
<th>MSHA Recorded Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Metal Nonmetal</td>
<td>Coal</td>
</tr>
<tr>
<td>2012</td>
<td>870</td>
<td>2,226</td>
</tr>
<tr>
<td>2013</td>
<td>938</td>
<td>2,696</td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Fatalities</th>
<th>Fatalities</th>
<th>Fatalities</th>
<th>Rate*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>870</td>
<td>2,226</td>
<td>3,096</td>
<td>7.2</td>
</tr>
<tr>
<td>2013</td>
<td>938</td>
<td>2,696</td>
<td>3,634</td>
<td>11.0</td>
</tr>
<tr>
<td>2014</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Rate as Fatalities per 100,000 miners employed

**SOURCE:** THE NATIONAL SKI AREAS ASSOCIATION, MSHA
Key SME Focus Areas for 2017

- Health of the Society
- Educational Sustainability
- Local Section Engagement
- Public Perception
- Safety and Health
Eleven Consecutive Years of Operating Surplus Through 2015
Health of the Society - Membership

Age Distribution of SME in 2016
Health of the Society - Membership

16 States with the Larger Memberships

<table>
<thead>
<tr>
<th>2016 SME Members</th>
<th>CO</th>
<th>AZ</th>
<th>NV</th>
<th>UT</th>
<th>MN</th>
<th>PA</th>
<th>CA</th>
<th>VA</th>
<th>TX</th>
<th>WA</th>
<th>MO</th>
<th>FL</th>
<th>NM</th>
<th>IL</th>
<th>KY</th>
<th>WV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,419</td>
<td>1,250</td>
<td>807</td>
<td>501</td>
<td>473</td>
<td>469</td>
<td>455</td>
<td>373</td>
<td>343</td>
<td>281</td>
<td>266</td>
<td>233</td>
<td>226</td>
<td>213</td>
<td>194</td>
<td>188</td>
</tr>
</tbody>
</table>
Health of the Society - Membership

80% of Student Membership is in 13 States

Student Membership by State (80%)

- SD: 108
- NV: 95
- VA: 95
- CO: 85
- MO: 84
- UT: 57
- AZ: 53
- PA: 47
- KY: 43 (red)
- MT: 43
- IL: 36
- WV: 32
- MN: 26

2016 Student Membership
## Health of the Society - Membership

### SME Membership by Division, Dec 31, 2016

<table>
<thead>
<tr>
<th>Divisions by Operational Functions</th>
<th>Divisions by Commodity</th>
<th>Divisions by Activity</th>
<th>Unaffiliated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health &amp; Safety</td>
<td>Environmental</td>
<td>Mining &amp; Exploration</td>
<td>Metallurgical &amp; Mineral Processing</td>
</tr>
<tr>
<td>2015</td>
<td>1997</td>
<td>1949</td>
<td>1948</td>
</tr>
</tbody>
</table>

![Graph showing membership by division](image)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>118</td>
<td>1,037</td>
<td>4777</td>
<td>1,967</td>
<td>1,599</td>
<td>910</td>
<td>1,085</td>
<td>619</td>
</tr>
</tbody>
</table>
Health of the Society - Membership

**SME Membership and Production Value for Metal Mines**

**Membership and Top 15 Production Value Predominantly Nonmetal States**

Source: 2017 USGS Mineral Commodity Summaries
Health of the Society - Membership

SME Coal Division Compares Well with Coal Employment as Reported by MSHA

Source: MSHA
Total SME Membership Lags Industry Employment, ~ 3 year Lag

Health of the Society - Membership

Source: MSHA
Health of the Society - Membership

- International/Cyber Member
- Local Section Contest
- ACE nonmembers

SME MEMBERSHIP as of December 2016

- International Mining Professionals
  - 2,138 as SME Full Members
- 670 International and 988 U.S. Student Members
- 13,002 SME
- 2016 Annual Meeting 6,325
- KY Local Sections
  - 8,144 Local & National Members
  - 3,600 Local Only
- ACE nonmembers
Sunrise Over the Product Domes at East
What is Potash?
What is Potash?

Major Types of Potash Fertilizer and K₂O Content

- MOP: Muriate of Potash, 60%
- SOP: Sulfate of Potash, 50%
- SOP-Mg: Sulfate of Potash Magnesia, 22%
- NOP: Nitrate of Potash, 43%
What is Potash?

2016 Potash Consumption Top 3 Regions

Asia 30 to 35 million tpa of product
S. America 10 to 15 million tpa of product
N. America 9 to 10 million tpa of product
Potash Mineralization and Ores

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Composition</th>
<th>Percent K₂O</th>
<th>Specific Gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Potash Minerals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sylvite</td>
<td>KCl</td>
<td>63.2%</td>
<td>2.00</td>
</tr>
<tr>
<td>Carnallite</td>
<td>KCl·MgCl₂·6H₂O</td>
<td>16.9%</td>
<td>1.60</td>
</tr>
<tr>
<td>Langbeinite</td>
<td>K₂SO₄·2MgSO₄</td>
<td>22.7%</td>
<td>2.83</td>
</tr>
<tr>
<td>Polyhalite</td>
<td>K₂SO₄·2CaSO₄·MgSO₄·2H₂O</td>
<td>15.6%</td>
<td>2.77</td>
</tr>
<tr>
<td><strong>Accessory Potash Minerals</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kainite</td>
<td>KCl·MgSO₄·3H₂O</td>
<td>19.3%</td>
<td>2.10</td>
</tr>
<tr>
<td>Leonite</td>
<td>K₂SO₄·MgSO₄·4H₂O</td>
<td>25.7%</td>
<td>2.20</td>
</tr>
<tr>
<td>Schoenite</td>
<td>K₂SO₄·MgSO₄·6H₂O</td>
<td>23.4%</td>
<td>2.03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ore</th>
<th>Composition</th>
<th>Percent K₂O</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Potash Ores</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sylvinitite</td>
<td>Halite and sylvite</td>
<td>Typically &lt; 25</td>
</tr>
<tr>
<td>Carnallitite</td>
<td>Halite and carnallite</td>
<td>Typically &lt; 15</td>
</tr>
<tr>
<td>Hartsalz</td>
<td>Halite, sylvite, anhydrite, and kieserite</td>
<td>Typically &lt; 15</td>
</tr>
<tr>
<td>Brine</td>
<td>Potassium enriched brine</td>
<td>&gt; 0.5</td>
</tr>
</tbody>
</table>

Source: USGS, Orris 2014
Potash Processing

Processing Options

- Sylvite ores – flotation, hot leach crystallization, dense media pretreat
- Carnalite ores – reverse flotation, hot leach crystallization, selective decomposition
- Hartsalz ores – electrostatic separation, hot leach crystallization, flotation, selective decomposition
- Langbeinite ores – dense media, gravity, water leach
- Brine sources – evaporation, salt exchange
Potash Processing

Special Considerations

- Water soluble minerals and products
- High specific gravity and viscosity of brines
- High ionic strength of the brines
- Pseudo-phase equilibrium
- Unintended salting of brines
- Hydroscopic nature of sylvite
Potash Processing
Solubilities of Double Saturated Solution

Degrees Fahrenheit

Percent Solubility

NaCl
KCl

Potash Processing
Blue bars represent sea, lake or salar based production
Potash Processing

- Mine
  - Hoist
  - Crush / Grind
  - Deslime
  - Float
  - Leach
  - Debrine
  - Dry
  - Screen
  - Compact

- Thicken
- Filter

- Tailings or Brine Ponds
  - Standard Potash
  - Granular Potash

- Brines returned for desliming and flotation
- Sodium saturated brine
  - 95% Potash
  - Coarse size
- Fine size

- Salt
- Clays

- Filtered brines

- Screen
  - Coarse size
  - Fine size
Potash Mining

Underground mining

– Depths 1000 - 1300 m (3281 - 4270’)

– Plastic conditions
Potash Mining
Sizing & Desliming

- Sizing is critical
- Insoluble materials 0.5% to 12%
- Methods include
  - Multi-stage attrition scrubbing, screening and hydraulic classification
  - Flocculation & reverse flotation,
  - Complexing agents
- Brine clarity is extremely important
• Fatty amine collector, extender oil, frother
• Concentrate leach to make final grade
• Denver cells very common

<table>
<thead>
<tr>
<th>Reagent</th>
<th>g/tonne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amine</td>
<td>50 to 150</td>
</tr>
<tr>
<td>Oil</td>
<td>30 to 40</td>
</tr>
<tr>
<td>Frother</td>
<td>20 to 30</td>
</tr>
<tr>
<td>Depressant</td>
<td>200 to 300</td>
</tr>
</tbody>
</table>
Debrining and Drying

- Recovery of brine is critical to optimizing recovery
- Low moistures required to ensure product quality, especially with magnesium brines
- Minimization of breakage must be managed for friable materials
- Equipment choice, typically centrifuges 2 - 4% moisture
- Coat with anti-cake or de-dust post drying
Tails Management

- Washing tails
- Recovery of brine is critical to optimizing recovery
- Centrifuges, belt filters, pan filters
Potash Processing
Tails Management

- Stacked
- Backfill
- Marine
- Riverine
Potash Processing

Agglomeration
## Potash Processing

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>SIZE $d_{50}$ (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premium – Pellet</td>
<td>2.70</td>
</tr>
<tr>
<td>Granular</td>
<td>2.70</td>
</tr>
<tr>
<td>Standard</td>
<td>1.05</td>
</tr>
<tr>
<td>Fine Standard</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Langbeinite:
- Coarse fine split
- Dense media for coarse
- Reflux classifier for fines
- Pelletize fine materials

![Premium](image1.png) ![Granular](image2.png)
Processing Options

- Carnalite ores – reverse flotation, hot leach crystallization, selective decomposition
  
  $\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$

- Hartsalz ores – electrostatic separation, hot leach crystallization, flotation, selective decomposition
Educational Sustainability

Fundraising Challenge for SME Foundation

Annual Fundraising Needed to Maintain Fund Balances

- 2016: $1,696,000
- 2017: $2,106,000
- 2018: $2,127,000
- 2019: $2,148,000
- 2020: $1,980,000
- 2021: $1,622,000
- 2022: $1,265,000

Graph shows the annual fundraising needed to maintain fund balances over the years from 2016 to 2025.
Fundraising Challenge for SME Foundation

Educational Sustainability